RESEARCH NOTE

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CAN AUGER PLANTING IMPROVE SURVIVAL OF DOUGLAS-FIR SEEDLINGS?

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ABSTRACT

Survival and apparent vigor of Douglas-fir seedlings were compared after: (1) hoe planting of root-trimmed seedlings; (2) as above, plus manual site preparation; and (3) auger planting of untrimmed seedlings. After two growing seasons, survival with method (3) but not (2) was significantly greater than survival with method (1). After the third season, survival differences were no longer statistically significant. Survival percentages were 40, 52, and 60 for methods (1), (2), and (3), respectively; and 50, 85, and 67 percent of the survivors were judged healthy. These results are discussed in relation to survival and cost data from other trials of auger versus hoe planting.

INTRODUCTION

Planting root-pruned seedlings with a hoe is the most common planting method used in the Pacific Northwest, but there is increasing interest in planting seedlings in holes dug by power auger. This interest has been intensified by demands for higher survival and more rapid growth of planted stock, improvement of lightweight power augers, and some regional evidence that auger planting may reduce the cost per surviving seedling.1/

1/ Dahl, Harold. Mechanical augers for tree planting on adverse sites. British Columbia Reforest. Board, Tree Farm Forest. Comm. 1966, Reforest. Work Proc. 6 pp. 1966.

A small-scale trial was initiated on an extensively distributed forest soil in southwestern Oregon to measure possible benefits from auger planting over regular or modified hoe planting of Douglas-fir on adverse sites. First-, second-, and third-year survival and apparent vigor are reported and discussed in relation to other trials comparing hoe and auger planting of Douglas-fir in western Washington and Oregon.

MATERIALS AND METHODS

Study Area

The study was located on a recent clearcut in the Cascade Range of southwestern Oregon. This clearcut--near Steelhead Creek, Steamboat Ranger District, Umpqua National Forest--was logged in the summer and burned and planted in the fall of 1963, 2 years before the study began. The study was conducted within a 1-acre, deer- and rabbit-proof exclosure at an elevation of 2,500 feet on a southeasterly, 20-percent slope. The soil (probably Dumont loam) was a dark, reddish-brown, well-aggregated, "shotty" loam developing on red-colored tuff with slight admixture of basalt colluvium.

Methods

Each of three groups of 25 seedlings was planted according to one of the following methods:

(1) Normal or hoe planting of root-trimmed seedlings.
(2) As above, plus removal of the upper 6 inches of soil in a 2-foot radius around the final seedling location prior to planting.
(3) Auger planting of untrimmed seedlings.

Thus, normal planting (1) was compared with two alternatives aimed at increasing seedling access to available soil moisture. Scraping aside the "shotty," upper soil layer in (2) permitted planting the pruned root system in a deeper, finer textured soil horizon and delayed reestablishment of competing vegetation. Auger planting of seedlings with untrimmed roots in (3) placed a longer, intact root system deeper into the soil.

Study Installation

In early December 1965, approximately 100 seedlings (2-1) of a local seed source were lifted from a nearby transplant bed. On the following day, 75 of these seedlings of comparable size and vigor were divided into three groups; each group was randomly assigned a treatment.

Two of the three groups were root-trimmed to reduce roots from 13 inches (± 3) to 8 inches in length. Each group was then packed with moist sphagnum moss in a plastic bucket.

One seedling for each method was planted at each of 25 locations within the exclosure. At each location, the three methods were randomized and the seedlings were planted 4 to 5 feet apart under comparable conditions in regard to stumps, logs, soil disturbance, and apparent intensity of past slash burning. All vegetation taller than 6 inches and within 3 feet of a seedling was grubbed out with a planting hoe. All planting was done by one person, one method at a time. For method (3), the last group planted, a 4-inch-diameter hole approximately 18 inches deep was bored with a power auger.

Data Collection and Analysis

Seedling survival and apparent vigor were recorded at monthly intervals throughout the first growing season (1966). Additional observations were made at the beginning (May) and end (November) of the second and third growing seasons. Number of all survivors and of healthy survivors (those seedlings whose needles were nonchlorotic and at least three-fourths inch long) were analyzed statistically.

RESULTS

Survival and Vigor

Survival percentage throughout the 3 years was greatest with auger-planted untrimmed stock (3), and somewhat less with hoe-planted root-trimmed seedlings and site preparation (2) (table 1). Survival percentage was consistently lowest with hoe-planted root-trimmed seedlings (1). Of the 25 seedlings planted by each procedure, 84 percent survived the first growing season in (3) and (2), compared to 56 percent in (1). This difference was statistically significant. Losses during the following winter and second growing season reduced survival percentages to 76, 52, and 40 in (3), (2), and (1), respectively; survival in (3) remained significantly greater than (1) and became significantly greater than (2). Survival of (2) was no longer significantly different from that of normal hoe planting without site preparation. After three growing seasons, differences in seedling survival remained but were no longer statistically significant. Survival percentages were 60, 52, and 40 in treatment (3), (2), and (1), respectively.

The number and proportion of healthy seedlings--those of normal stature and with needles of normal length and nonchlorotic color--increased with successive growing seasons and were consistently greater in (3) and (2) than in (1) (table 1). At the end of three growing seasons, the

proportion of healthy trees was 67, 85, and 50 percent, respectively. Although the differences are not statistically significant, they do indicate greater potential for survival in (2) and (3) seedlings.

Table 1.--*Number of surviving and of healthy 2-1 Douglas-fir seedlings planted by three different methods*[1/]

Methods	First growing season		Second growing season		Third growing season	
	Alive	Healthy[2/]	Alive	Healthy[2/]	Alive	Healthy[2/]
(1) Root-pruned, hoe-planted	14	0	11	1	10	5
(2) Root-pruned, hoe-planted, with surface soil removed	21	4	13	6	13	11
(3) Unpruned, auger-planted	21	5	19	9	15	10
Total	56	9	43	16	38	26

Note: Means connected by a vertical line are not significantly different at the 5-percent level.

[1/] 25 seedlings per method.

[2/] Seedlings had normal stature and needles that were nonchlorotic and at least 3/4 inch long.

Timing and Probable Causes of Seedling Mortality

Most mortality in the normal, hoe-planted seedlings occurred during the first growing season. In (2) and (3), however, most mortality was delayed to the second and third growing seasons, respectively (table 2).

Causes of seedling mortality may be surmised. Lack of root regeneration, resulting in reduced moisture and nutrient uptake, was a probable cause of mortality. Root regeneration (postplanting root growth) was evaluated by

examining the excavated root systems of dead seedlings. Of the 37 seedlings which died by the end of the third growing season, only six evidenced any root regeneration (table 2).

Table 2.--*Number of dead seedlings by planting method*[1/] *and after indicated growing season*

Method	First growing season	Second growing season	Third growing season	Total
(1) Root-pruned, hoe-planted	11 (1)[2/]	3 (0)	1 (1)	15 (2)
(2) Root-pruned, hoe-planted, with surface soil removed	4 (0)	8 (1)	0 (0)	12 (1)
(3) Unpruned, auger-planted	4 (0)	2 (1)	4 (2)	10 (3)
Total	19 (1)	13 (2)	5 (3)	37 (6)

[1/] 25 seedlings per method.

[2/] Figures in parentheses indicate number of dead seedlings showing postplanting root growth.

Snow and frost damage may have contributed to seedling mortality, but the evidence is not strong. Wet snowfall during the first winter depressed two-thirds of all seedlings and most retained a bowed stature through the first growing season. Damaging frost occurred in June and September of the first growing season. Damage from frost and/or snow was about equal in all methods, and the proportion of seedlings which subsequently recovered or died was similar.

DISCUSSION AND CONCLUSIONS

Where can auger planting improve survival of Douglas-fir seedlings? Planting method and stock should be fitted to meet anticipated regeneration problems at each site. On relatively favorable sites, such as in coastal areas of western Washington and Oregon and on northerly aspects in the Cascade Range, hoe planting 2-0 Douglas-fir seedlings may commonly

provide regeneration at a low cost per established tree. On unfavorable sites, however, successful regeneration requires additional effort such as closer supervision of crews, site preparation, auger or container planting, use of older seedlings, control of competing vegetation, and protection from animals. It is the forester's responsibility to determine where and what extra effort and cost are necessary to achieve satisfactory stocking and cost per established tree.

The present test was conducted on a productive but difficult-to-regenerate site in southwestern Oregon. The results of this small, relatively sensitive field experiment can be judged by examination of trends of survival and by use of the proportion of healthy seedlings as an index of survival potential. By the end of the third growing season, survival percentages were 40, 52, and 60 for methods (1), (2), and (3), respectively. Although these differences among methods were no longer statistically significant, the greater proportion of surviving and of healthy seedlings in (2) and (3) after each growing season are bases for recommending further testing of site preparation or auger planting as alternatives to regular hoe planting on similar, adverse sites.

Two previous studies conducted within this exclosure had demonstrated regeneration problems with either hoe planting or seed spotting. For example, in one trial conducted by Umpqua National Forest personnel, only 28 percent of planted 2-0 Douglas-fir survived the first growing season.[2/] This is considerably less survival than that attained with hoe planting 2-1 stock in this present study. In the second study, 8 percent of the seedlings which germinated in prepared seed spots survived the first growing season (compared to 10, 36, and 38 percent at three other exclosures in the Umpqua River drainage).[3/] Poor germination and survival at Steelhead Creek were associated with earlier (1 month) and higher (163°F. versus 150°F.) maximum soil surface temperatures (determined with "Tempils," commercial temperature pellets) than at the other three exclosures. There was also more rapid and complete drying of the upper 4 inches of soil.

The present study was not designed to measure gains in survival from auger planting of seedlings with smaller root systems, because an additional method (auger planting root-trimmed stock) was not tested. Thus, increased survival and vigor in (3) could be due to untrimmed roots, method of planting, or both. There is some basis for expecting

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[2/] Personal communication with Ray Zalundardo, September 1966.

[3/] Data on file at Pacific Northwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, Olympia, Washington.

comparable results with root-trimmed stock. Huntly[4/] concluded that root pruning (trimming) as much as one-half the shoot height did not reduce survival of Douglas-fir seedlings transplanted in the nursery. Moreover, results of a field trial discussed later in this paper suggest that root trimming 2-2 transplants--a common nursery practice--did not reduce survival at an adverse site in south-central Washington when planting was carefully done. If further testing supports this interpretation, then auger planting could be more cheaply and probably better done on an operational basis by use of stock which is root trimmed at the nursery.

The results of the present study can be related to survival and cost data from other trials to help determine where auger planting might reduce the cost per surviving seedling of Douglas-fir. On adverse sites in the Bear Springs Ranger District of the Mount Hood National Forest, auger planting of root-trimmed stock has apparently provided better survival than has hoe planting.[5/] For example, on five clearcut units, first-year survival after hoe planting ranged from 1 to 9 percent. Replanting these same units by auger resulted in 35- to 55-percent survival. Contract planting costs per surviving tree were approximately $0.65 for hoe planting and $0.18 for auger planting. Obviously these comparisons are confounded by numerous factors since augers and hoes were not used in the same years. Despite these shortcomings, however, the consistent results of these and other local trials support this District's preference for auger planting on adverse sites with gentle to moderate slopes and nongravelly soils. Even though contract costs are about 50 percent greater for auger planting, use of this method on adverse sites of this District would probably result in a manyfold increase in survival of Douglas-fir seedlings.

At locations farther north, other comparisons of planting Douglas-fir have not demonstrated increased survival from auger planting. On the Glenwood District in south-central Washington, the Department of Natural Resources planted 2-2 Douglas-fir in a 4-year-old clearcut located on a 30-percent slope of southeast exposure. In past District experience, this was a difficult site to regenerate. Survival

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4/ Huntly, J. H. Assessment of survival and growth prospects of seedlings of Douglas-fir, *Pseudotsuga menziesii*. 55 pp. 1960. (Unpublished M.F. thesis on file at Faculty of Forestry, Univ. British Columbia, Vancouver, B.C., Canada.)

5/ Personal communication with Paul F. Schuller, November 13, 1968.

percentages based on 200 seedlings per method (four rows of 50 seedlings each) are as follows:[6/]

Method	Percent survival	
	First year	Third year
Hoe, roots trimmed	82	70
Auger, roots untrimmed	75	66

Compared to survival of stock planted on an operational basis in the same general area, survival of hoe-planted stock in this study was good. Most likely, these results are attributable to close supervision and good workmanship.[7/] Although greater survival percent was anticipated for auger planting, no additional gain was achieved from auger planting this larger stock.

A pilot project by Weyerhaeuser Company on a scarified site I north slope in southwestern Washington demonstrated little increase in survival with auger planting.[8/] Following mechanical scarification, 2-0 Douglas-fir were planted by hoe or power auger; the corresponding number of seedlings planted were 25,000 and 18,000. Second-year survival of a staked 10-percent sample was 89 and 91 percent, respectively, for hoe and auger planting. This 2-percent improvement in percentage of survival with auger planting is not likely to offset the costs of auger planting which were approximately 20 percent greater.

In summary, current regional experience concerning the benefits of planting Douglas-fir with auger is limited and does not support general application of this tool. Practical gains from auger planting are most likely on sites where soil moisture is deficient, but where topography and soils are favorable for auger operations. Suggesting that auger planting generally provides a greater allowance for error, some investigators urge use of mechanical augers instead of planting hoes by inexperienced or inadequately motivated planting crews.[9/] Additional testing is necessary before we can determine and subsequently predict specific planting conditions under which the additional expense of auger planting Douglas-fir is justified.

6/ Personal communication with J. M. Finnis, November 1968.

7/ Ibid.

8/ Personal communication with William Schmidt, November 15, 1968.

9/ Personal communication with J. M. Finnis, November 1968, and Paul F. Schuller, November 13, 1968.